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Technical Report No. 9

COMPARISON OF CORD LOADS WITH A 24 x 7.7 TYPE VII AIRCRAFT TIRE ON GROOVED AND SMOOTH RUNWAY SURFACES

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I. INTRODUCTION

In recent years several comprehensive research programs have investigated the effectiveness of runway grooving as a means for increasing tire traction under operational conditions. A compilation of many of these efforts was made through the Conference on Pavement Grooving and Traction Studies at Langley Research Center in November 1968.[3]

Several important characteristics of runway grooving were discussed at this conference. For instance, aircraft test results indicated that transverse runway grooves provide greatly increased aircraft braking and steering capability for wet, flooded, and slush-covered runways. It was also pointed out that grooves caused no significant increase in tread wear or operational damage even though chevron-type cuts can be developed in the tire tread at higher slip ratios. In addition, it was reported that the overall aircraft ground handling and stopping characteristics on the grooved surface showed a dramatic improvement over those on corresponding ungrooved surfaces, with no observable adverse characteristics from the pilots' point of view.

The purpose of this paper is to add to the basic knowledge of tire performance on grooved surfaces. This is accomplished by discussing some experimental measurements of tire cord loads on grooved and ungrooved surfaces. Such characteristics as tire stress distribution and fatigue properties are functions of tire cord load, and thus it is important to determine whether or not cord load is adversely affected by the presence of the grooved surfaces. These measurements were made possible by the successful development and application of a suitable cord load transducer.

II. SUMMARY OF RESULTS

The cord loads developed in one size of aircraft tire are not affected to any significant extent by running on a grooved surface. This statement is based on test results for a 24 x 7.7 10 PR Type VII tire, under slow-rolling conditions, on both aluminum and concrete grooved surfaces. The groove configurations were all rectangular or chamfered grooves ranging from 3/16 in. by 3/16 in. on 1 in. centers to 3/8 in. by 3/16 in. on 1 in. centers. These tests were conducted on a small flat-plank machine using a tire instrumented with small cord load transducers. A complete tabular summary of all results is included for reference.

III. TRANSDUCER AND TEST SAMPLE CONSTRUCTION

The data presented in this paper was obtained from a tire with force transducers installed during building of the tire. These transducers consist of small, mechanically stiff load cells inserted in series with the tire cord by means of cutting the cord and bonding each cut end to opposite ends of the transducer. These transducers are made from small berylium-copper tubing which has an inside diameter nearly equal to the outside diameter of the tire cord used. The hollow center section of the tubing is instrumented with conventional foil strain gages. Such a transducer may be calibrated before use, giving an experimental relationship between cord load and signal output which should be linear for a well designed transducer. This linear relationship can then be used to interpret signal output in terms of cord load after the transducer has been built into the tire.

A sketch of the transducer design used in these tests is given in Fig. 1. A detailed description of the manufacture and application of this device has been given by Bourland, Clark, and Dodge.[1]

A 24 x 7.7 10 Ply Rating Type VII aircraft tire was built with a set of transducers implanted during the building process. The transducers were located at several meridional locations in alternate plies beginning with ply two. The discussion in the remainder of this paper centers around test results obtained from this tire.

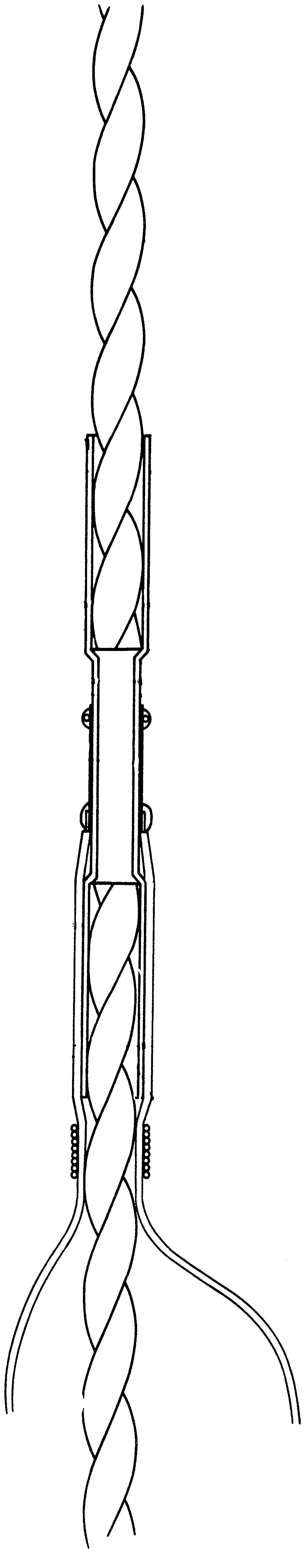


Fig. 1. Cord load transducer.

IV. TEST EQUIPMENT, PROCEDURES, AND RESULTS

The instrumented tire described above was subjected to a series of slow-rolling tests over grooved and ungrooved surfaces. The signal output from each force transducer was amplified and displayed on an x-y plotter during the load cycle of the tire. All of these tests were run on a small flat-plank machine at approximately one mile per hour at zero steer angle, see Fig. 2. Even though such speeds are much lower than those encountered during normal operations, the results of these tests are still valuable since previous studies have shown that many cyclic characteristics of cord loads are nearly independent of speed.[2]

Cord load is a function of inflation pressure and is shown in Fig. 3 for an unloaded tire. Such cord loads vary throughout the cross-section and these values serve as reference points for the loaded tire tests to be reported subsequently.

The nature of the cord load cycle varies throughout the tire also, and this is illustrated in Fig. 4. It may be seen that not only the form but the amplitude of the cord load cycle varies throughout the tire.

In all of the cord load plots there is a characteristic maximum cord load fluctuation which is indicated by d_1, d_2, and d_3 in Fig. 4. This absolute change is used as the criterion for comparison of cord loads developed while traversing grooved and ungrooved surfaces.

A 1 in. thick aluminum plate was used for the test surface. One side was left smooth while the other side was grooved. The grooves were 1/8 in. wide, 3/16 in. deep, and located on 1 in. centers, see Fig. 2. The test procedure

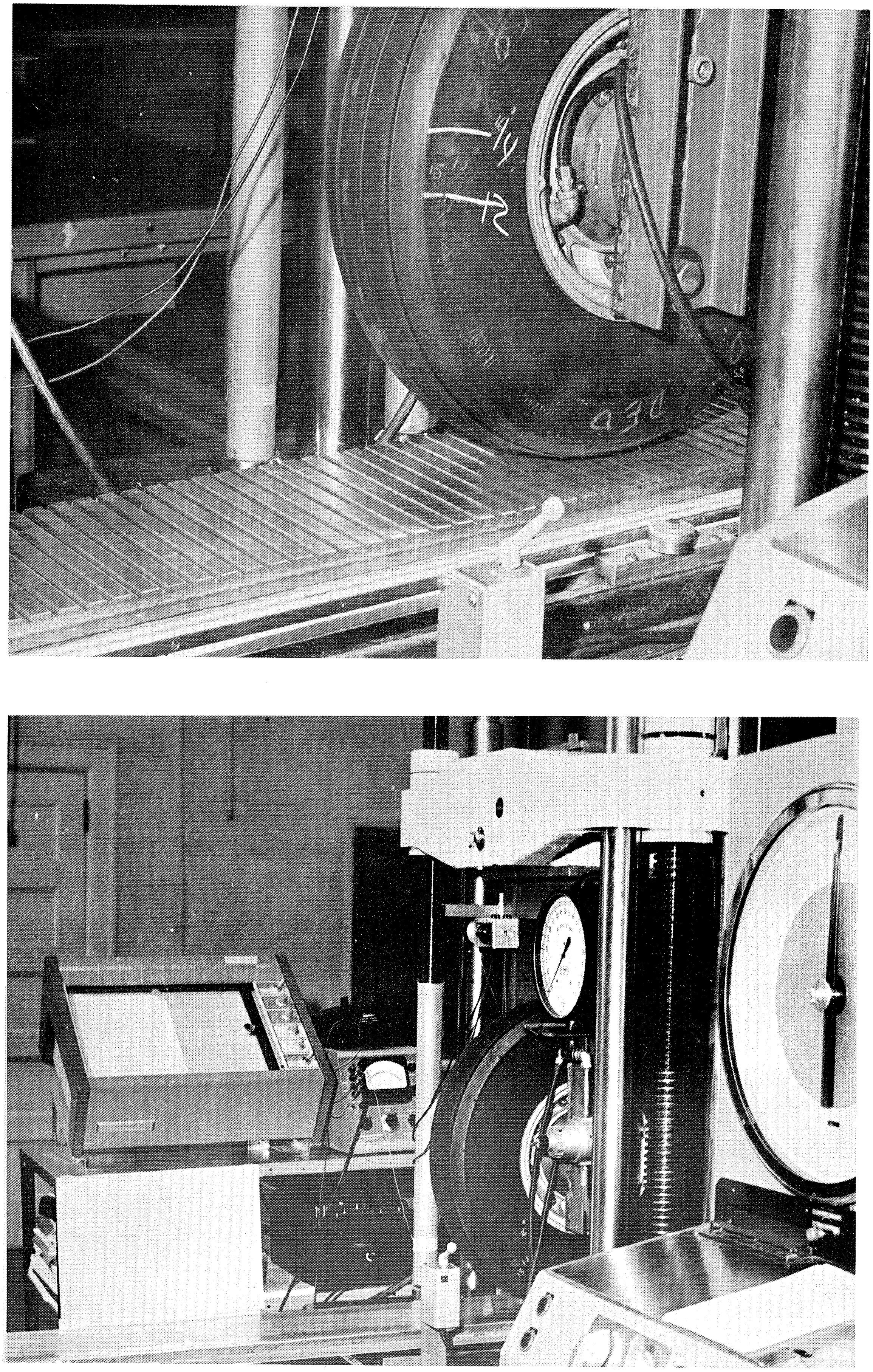


Fig. 2. Test apparatus—aluminum grooved surface.

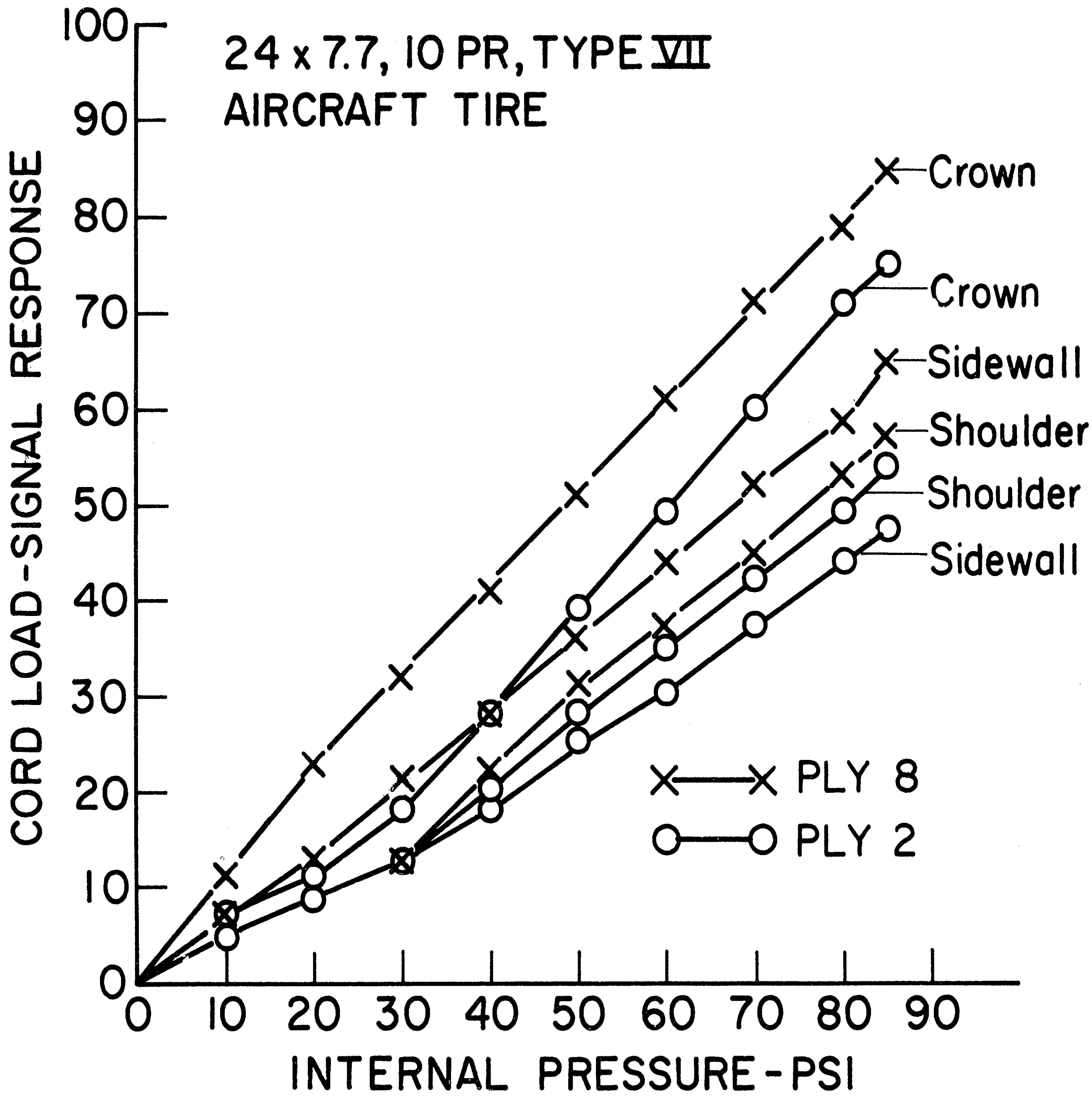


Fig. 3. Cord load vs. internal pressure.

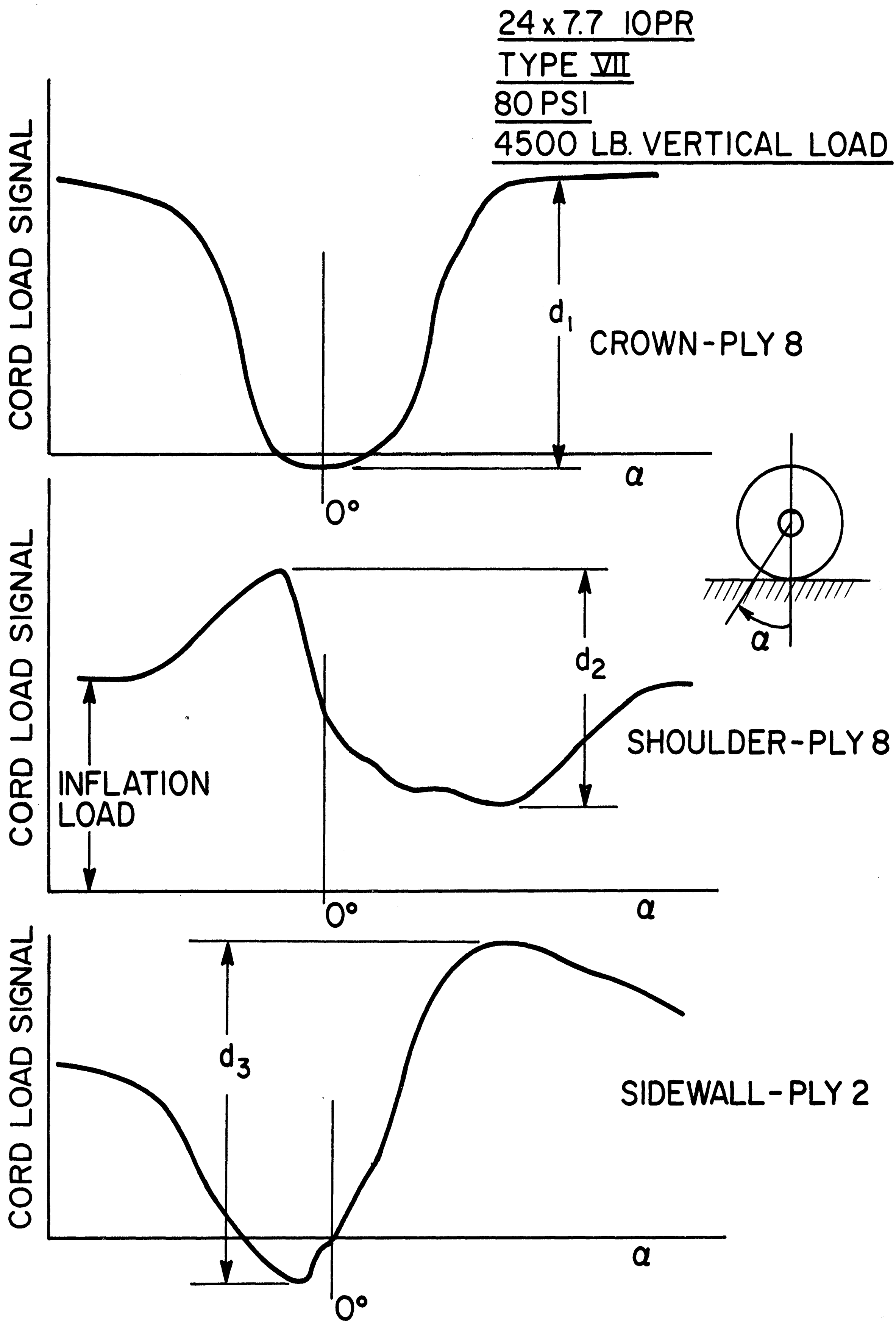


Fig. 4. Shapes of typical cord-load cycles.

was to inflate the tire to 80 psi, apply a vertical load of 4500 pounds, and run the tire through contact while recording the cord load continuously. This was done on the smooth side of the plate and then the plate was turned over and the test repeated on the grooved side of the plate. Upon completion of this test the plate was removed and the groove width increased by chamfering both sides of the groove with a 1/16 x 45° chamfer. The test was then repeated. Next the groove width was increased by 1/8 in. by milling out each groove. This obliterated the previous chamfer, but now gave a larger groove which could be used for the next test. It could then also be chamfered. This process was continued until the final groove size was 3/8 in. wide by 3/16 in. deep. A complete summary of this data and the differences observed is shown in Table I. The differences recorded here are defined as the differences between the grooved surface results and the ungrooved surface results divided by the ungrooved results. As may be seen, the cord load differences between grooved and ungrooved surfaces are extremely small. This is an indication that grooved surfaces will not adversely affect either the internal stress distribution or fatigue characteristics of slow-rolling tires, since both are functions of cord load.

A test program similar to the one described above was carried out on a concrete surface with 1/4 in. by 1/4 in. grooves located on 1 in. centers, see Fig. 5. The results from these tests were very similar to those recorded from the aluminum plate. A complete summary of these results is shown in Table II.

Since aircraft tires are subjected to a number of landings before being retreaded, it seemed necessary to make these cord load comparisons on a worn

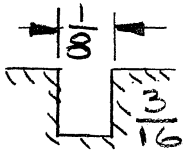
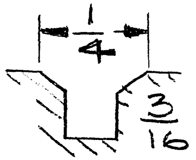
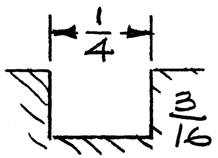
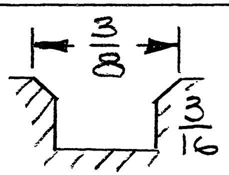
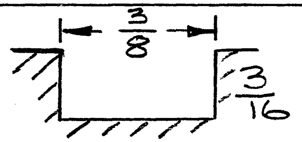
TABLE I

CORD LOAD COMPARISONS—GROOVED AND UNGROOVED SURFACES

24 x 7.7 10 PR Type VII

Aluminum Plank—80 psi—4500 lb Vertical Load

$$\% \text{ Diff} = \frac{\text{Cord Load Grooved Surface—Cord Load Ungrooved}}{\text{Cord Load Ungrooved Surface}}$$

Location						
					New	Buffed
	% Diff	% Diff	% Diff	% Diff	% Diff	% Diff
Sidewall Ply 2	7.4	5.2	2.1	--	-2.1	0
Shoulder Ply 2	0	1.5	1.1	2.1	0	--
Crown Ply 6	-3.0	0	3.1	-3.0	-3.1	--
Crown Ply 8	1.2	0	2.1	0	2.4	-2.3
Shoulder Ply 8	-1.5	3.0	0	1.5	1.5	-2.9

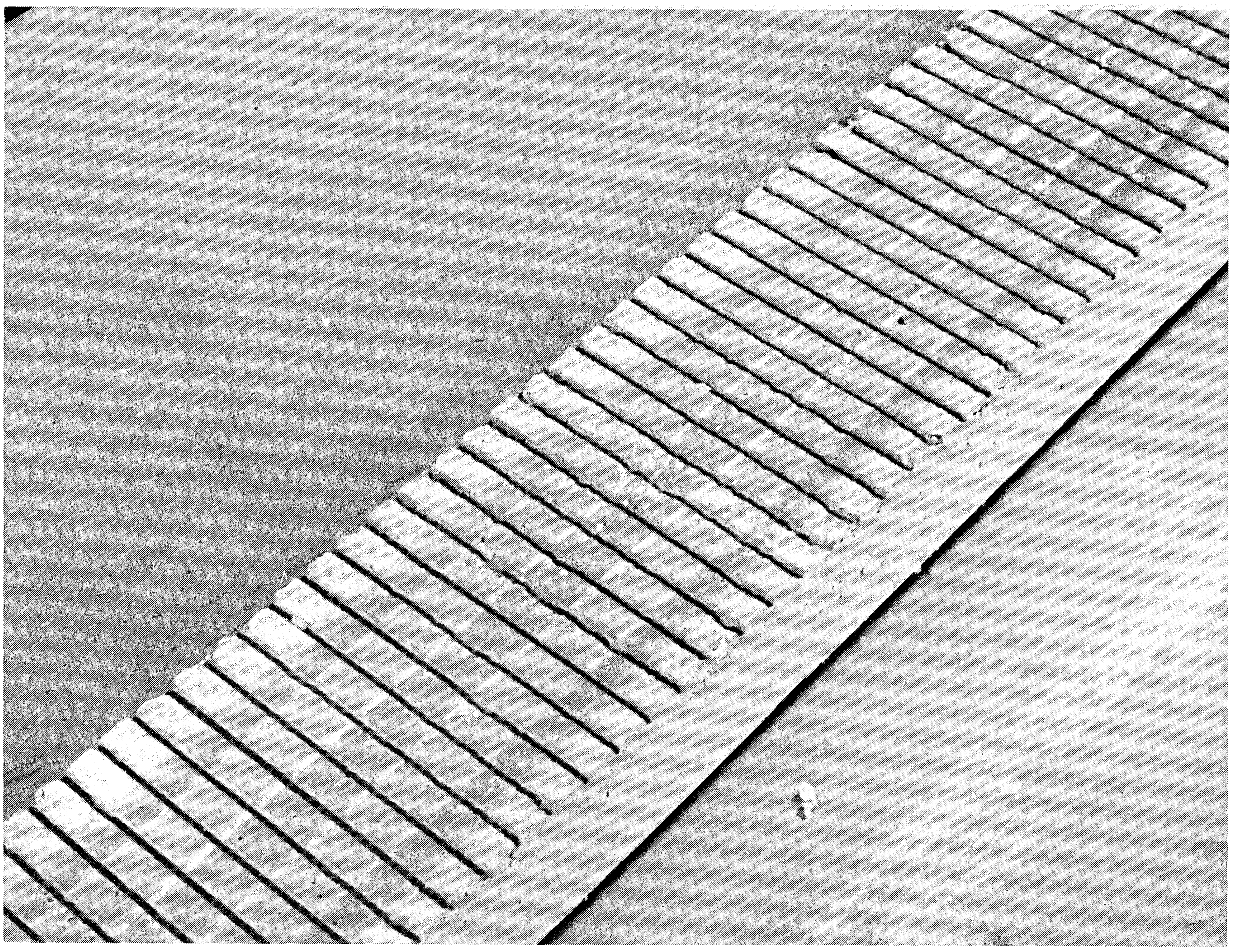


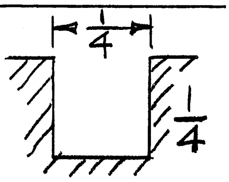
Fig. 5. Grooved concrete surface.

TABLE II

CORD LOAD COMPARISON

24 x 7.7 10 PR Type VII

Concrete Plank—80 psi—4500 lb Vertical Load

Location	
	% Diff
Sidewall Ply 2	2.2
Shoulder Ply 2	2.0
Crown Ply 6	2.8
Crown Ply 8	2.1
Shoulder Ply 8	-2.7

tire as well as the new tire described above. To do this, the instrumented tire was buffed down until the tread was approximately 1/16 of an inch above the bottom of the grooves. The tire was then subjected to the same tests described above on the aluminum surface with the 3/8 in. by 3/16 in. grooves. A summary of these results may be found in the last column of Table I. As may be seen, the differences are still relatively small, which indicates that the cord load is not seriously affected by the grooved surface at any time in the history of its wear.

The conclusion from these tests is that slow-rolling cord load characteristics are not affected to any appreciable degree by grooved surfaces on this particular type of aircraft tire. By implication, one would doubt that grooved runways would in general adversely affect the fatigue life of aircraft tires.

VI. REFERENCES

1. B. E. Bourland, S. K. Clark, and R. N. Dodge, "Development of a Textile Cord Load Transducer," ORA Report 01193-1-T, The University of Michigan, 1968.

2. Patterson, R. A., "The Measurement of Cord Tensions in Tires," Rubber Chem. and Tech. 42, No. 3, June 1969, p. 812.

3. "Pavement Grooving and Traction Studies," NASA SP-5073, A conference held at Langley Research Center, Hampton, Virginia, November 18-19, 1968.